Redox Tolerant Cathode for Solid Oxide Electrolysis Stacks, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

OxEon Energy proposes a combination of materials and engineering solutions to demonstrate the reduction-oxidation (redox) stability of a solid oxide electrolysis cathode during start up and operation. The redox tolerant cathode material will reduce system complexity, tolerate flow upset conditions, and provide flexibility in space based systems without a man-in-the-loop.

Solid oxide electrolysis stacks use nickel – zirconia composite cathode to reduce incoming oxidized species such as those available on Mars (e.g. carbon dioxide) to produce high purity oxygen. The device can also operate on co-electrolysis mode where the atmosphere CO_2 and water and other volatiles from extra-terrestrial soils can be processed together to produce oxygen and fuels such as methane for propulsion, regenerative power, and life support system applications. Present state of the art electrolysis stacks use a nickel-zirconia composite cathode. Nickel based electrodes are susceptible to oxidation by the feed gas (CO_2 or steam) at the inlet conditions unless reduced species (carbon monoxide or hydrogen) are also present. This necessitates a complex, recycle loop that introduces a fraction of the product gases to the inlet.

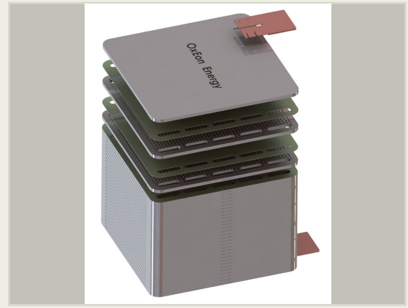
Prior attempts at developing an oxidation resistant cathode evaluated precious metal or ceramic oxides. They exhibited excellent stability in CO_2 and steam, but the performance of cells was significantly lower relative to nickel based electrode.

The proposed cathode material is expected to be stable in an oxidizing environment with little or no deleterious oxidation. This will allow a significant simplicity in electrolysis system design, facilitate the utilization of in situ resources to produce oxygen and fuels, resulting in the development of an enabling technology for future manned mission to Mars.

Anticipated Benefits

> The proposed technology when successfully demonstrated will enable production of oxygen by electrolyzing Mars atmosphere CO_2 and will co-produce carbon monoxide with a simpler system design. The device can also operate on co-electrolysis mode where the atmosphere CO_2 and water and other volatiles from extra-terrestrial soils can be processed together to produce oxygen and fuels such as methane for propulsion, regenerative power, and life support system applications.

A concept that directly aligns with the proposed project is combining non-carbon based electric generation with the co-electrolysis of steam and CO_2 and using the resultant synthesis gas ($CO + H_2$) to produce synthetic fuels using the fuels synthesis reactor. This allows highly efficient conversion and storage of vast quantities of renewable energy in chemical and fuel form. The



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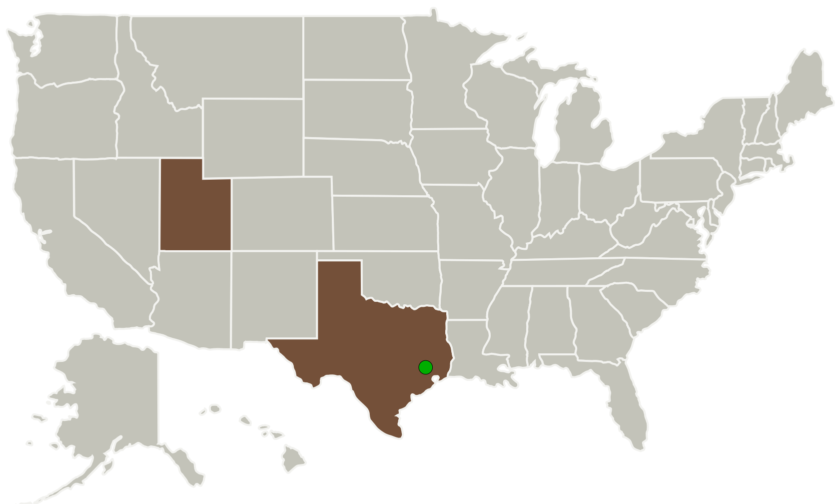
technology can also produce hydrogen from steam electrolysis at very high efficiencies.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
OxEon Energy, LLC	Lead Organization	Industry	North Salt Lake, Utah
Johnson Space Center(JSC)	Supporting Organization	NASA Center	Houston, Texas

Primary U.S. Work Locations	
Texas	Utah

Project Transitions

July 2018: Project Start

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Organization:

OxEon Energy, LLC

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Project Management

Program Director:

Jason L Kessler

Program Manager:

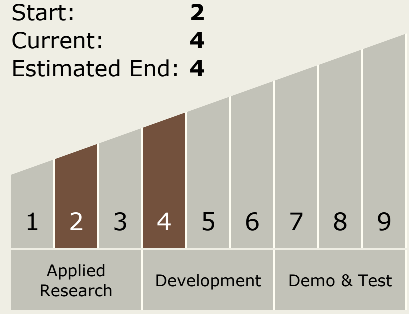
Carlos Torrez

Principal Investigator:

Singaravelu Elangovan

Technology Maturity (TRL)

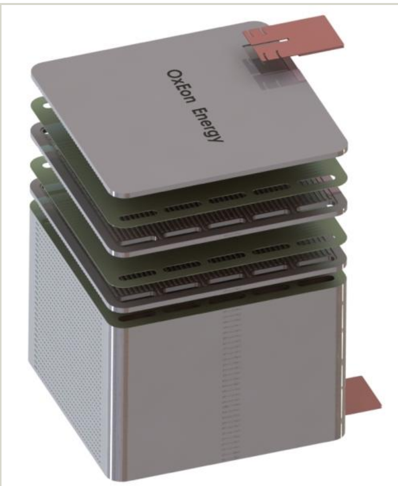
Start: **2**
Current: **4**
Estimated End: **4**



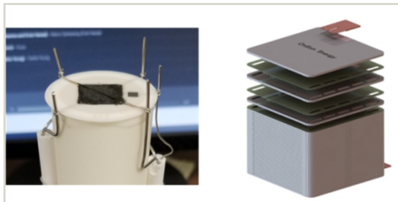
February 2019: Closed out

Closeout Documentation:
- Final Summary Chart*(https://techport.nasa.gov/file/141260)*

Images



Briefing Chart Image
Redox Tolerant Cathode for Solid Oxide Electrolysis Stacks, Phase I
(https://techport.nasa.gov/image/132221)



Final Summary Chart Image
Redox Tolerant Cathode for Solid Oxide Electrolysis Stacks, Phase I
(https://techport.nasa.gov/image/134247)

Technology Areas

Primary:

- TX07 Exploration Destination Systems
  - └ TX07.1 In-Situ Resource Utilization
    - └ TX07.1.3 Resource Processing for Production of Mission Consumables

Target Destination

Mars